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# IP-1 Certification of Cargo Containers

L. Hagler

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## Disclaimer



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# Engineering Note

## *Cargo Container Qualification to IP-1 Requirements*

**ERD10-500040-AA**


**Prepared by:**
**Lisle Hagler**
**Engineering Technologies Division**


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## Distribution

Dennis Barrett (L-123)
Kathy Bochenski (L-650)
Joe Byrne (L-786)
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## Purpose and Scope

The purpose and scope of this Engineering Note is to demonstrate that the structural design of the cargo container complies with the IP-1 container requirements of 49 CFR 173.410 as required by CFR 173.411 (b) [1].

## General Design Requirements for Radioactive Packagings Summary

(a) The package can be easily handled and properly secured in or on a conveyance during transport.

(b) Each lifting attachment that is a structural part of the package must be designed with a minimum safety factor of three against yielding when used to lift the package in the intended manner, and it must be designed so that failure of any lifting attachment under excessive load would not impair the ability of the package to meet other requirements of 49 CFR 173.410. Any other structural part of the package which could be used to lift the package must be capable of being rendered inoperable for lifting the package during transport or must be designed with strength equivalent to that required for lifting attachments.

(c) The external surface, as far as practicable, will be free from protruding features and will be easily decontaminated.

(d) The outer layer of packaging will avoid, as far as practicable, pockets or crevices where water might collect.

(e) Each feature that is added to the package will not reduce the safety of the package.

(f) The package will be capable of withstanding the effects of any acceleration, vibration or vibration resonance that may arise under normal conditions of transport without any deterioration in the effectiveness of the closing devices on the various receptacles or in the integrity of the package as a whole and without loosening or unintentionally releasing the nuts, bolts, or other securing devices even after repeated use.

(g) The materials of construction of the packaging and any components or structure will be physically and chemically compatible with each other and with the package contents. The behavior of the packaging and the package contents under irradiation will be taken into account.

(h) All valves through which the package contents could escape will be protected against unauthorized operation.

(i) For transport by air – not applicable

## IP-1 Qualification Determination Results

(a) The Cargo Containers are equipped with fork pockets to allow easy handling with a forklift. Securement to a flat-bed truck is routinely accomplished through use of load locks or strapping. This satisfies 49 CFR 173.410(a).

(b) The Cargo Containers have been certified by the American Bureau of Shipping and the Bureau of Veriatass [5,6] to have been manufactured and tested to ISO Standards 6346, 1496-1, 668, and 1161. This means that the Cargo Container's lifting attachments are load-tested to 33,550 lbf each and will not plastically deform under this applied load [3, 4].

**The maximum gross weight of a container will not exceed 45,000 lbf during LLNL use.** The structural analysis in Appendix 1 shows that the resulting maximum load on each lifting attachment is 11,250 lbf, which is 1/3 the test load. Since the lifting attachments do not plastically deform under the test load, there is a minimum safety factor of 3 against yielding. Requirement 49 CFR 173.410(b) is satisfied.

(c) The external surface of the containers, which are free of protruding features, can be easily decontaminated since the surfaces are smooth, painted steel. This satisfies 49 CFR 173.410(c).

(d) Visual inspection of the containers confirms that there are no pockets or crevices where water might collect. This satisfies 49 CFR 173.410(d).

(e) There are no added features to the package that will reduce its safety. This satisfies 49 CFR 173.410(e).

(f) The Cargo Container has wooden flooring. This wood flooring is not part of the closure structure (door and frame) and the Cargo Container will not contain any granular material at any time. Therefore the containment of contents during normal transport depends solely on the structural integrity of the closure. Structural analysis of the container closure (see Appendix 1) demonstrates that the structural integrity of the closure does not deteriorate when subjected normal transport vibration loads [2]. This satisfies 49 CFR 173.410(f).

(g) NTSWAC which prohibits the shipment of incompatible waste. The contents will be verified that it meets the NTSWAC requirement once the container is loaded. This will satisfy 49 CFR 173.410(g).

(h) Not Applicable

(i) Not Applicable

## Conclusion

The Cargo Container meets all the applicable structural design requirements of 49 CFR 173.410 plus those of 49 CFR 173.411(a, b). It is eligible to be certified as IP-1.

## References

1. Code of Federal Regulations, Dept. of Transportation, 49 CFR 173.410 and 173.411(a-b), 2009.
2. Singh, S.P. and Marcondes, J., "Vibration Levels in Commercial Truck Shipments as a Function of Suspension and Payload", ASTM JOTE, November 1992.
3. ISO 1496-1: Series 1 Freight Containers-Specification and Testing-Part 1: General Cargo Containers for General Purposes, 5th Edition, 1995.
4. ISO 668: Series 1 Freight Containers-Classification, Dimensions and Ratings, 5th Edition, 1995.
5. Specification S-006 *Quality and Inspection Requirements for New or Like New Cargo Containers*, latest revision
6. Procedure P-003 *Conducting PATS Receiving Inspection Procedure*, latest revision

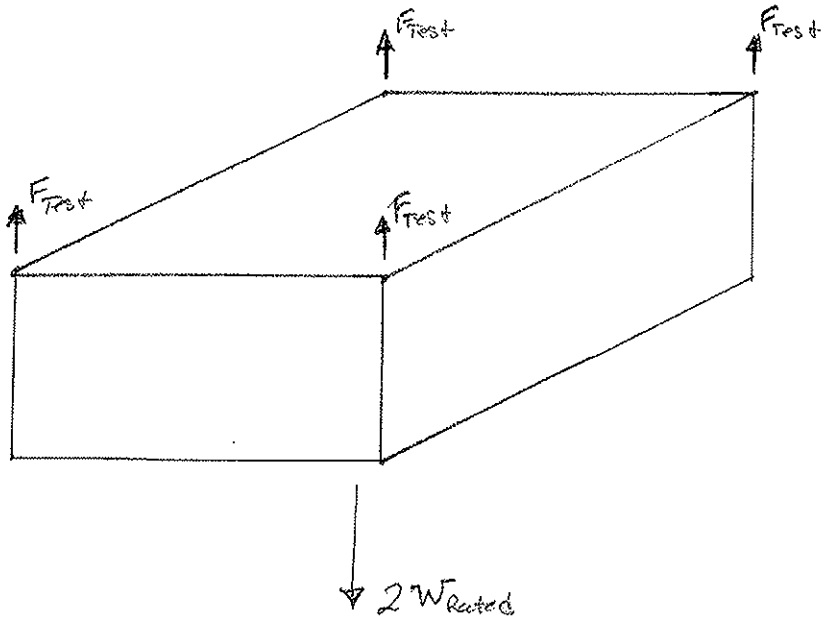
# APPENDIX 1

# Structural Analyses Demonstrating Qualification to IP-1 Standard

# Lifting Attachment Structural Analysis

$W_{Rated} = 67,100$ lbf

$W_{Max} = 45,000$ lbf.




$$\rightarrow F_{Test} = \frac{1}{4}(2W_{Rated}) = \frac{1}{2}W_{Rated} = \underline{33,550 \text{ lbf}}$$

$$\rightarrow F_{Max} = \frac{1}{4}W_{Max} = \underline{11,250 \text{ lbf}}$$

$$\therefore \eta = \frac{F_{Test}}{F_{Max}} = \frac{33,550}{11,250} = \underline{3}$$

**Structural Analysis of Cargo Container Closure System**

Figure 1 is a photo of the cargo container closure. It consists of two hinged doors compressing a gasket when closed and secured by two securing bars each. The securing bars lock into anchor lugs welded onto the rigid door frame.

Figure 1. Cargo Container Closure

The closure is subject to random road vibration while in transport on the bed of a flat-bed truck. A typical PSD plot corresponding to this vibration load is shown in Figure 2.

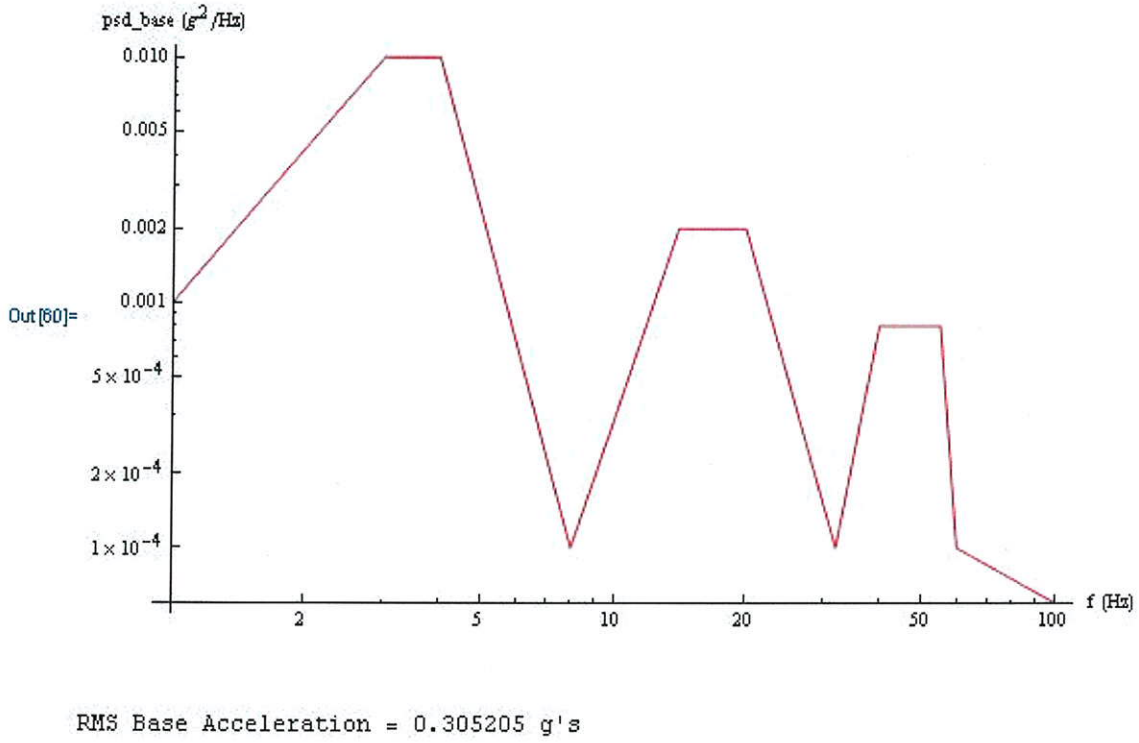



Figure 2. Road Vibration PSD for Flat-Bed Truck Bed

The door is modeled with shell elements which are constrained to the beam element securement bars by constraint equations. The door is constrained at four hinge points and the securement bars are constrained at their end-points. These constraints allow for rotation about the vertical. To add conservatism to the analysis, the remaining edges of the door are assumed to be free.

This loading corresponds to the normal conditions of transport (NCT). The structural integrity of the closure system is deemed adequate if the resulting stresses are at or below 1/3 yield and the reaction loads on the securement bars' anchor lugs generate acceptably low weld stresses.

The random loading results in the RMS displacement and *Von Mises stress shown in Figures 3 and 4. These displacements and stresses are quite low.

*Distortion Energy Theory of Ductile Failure

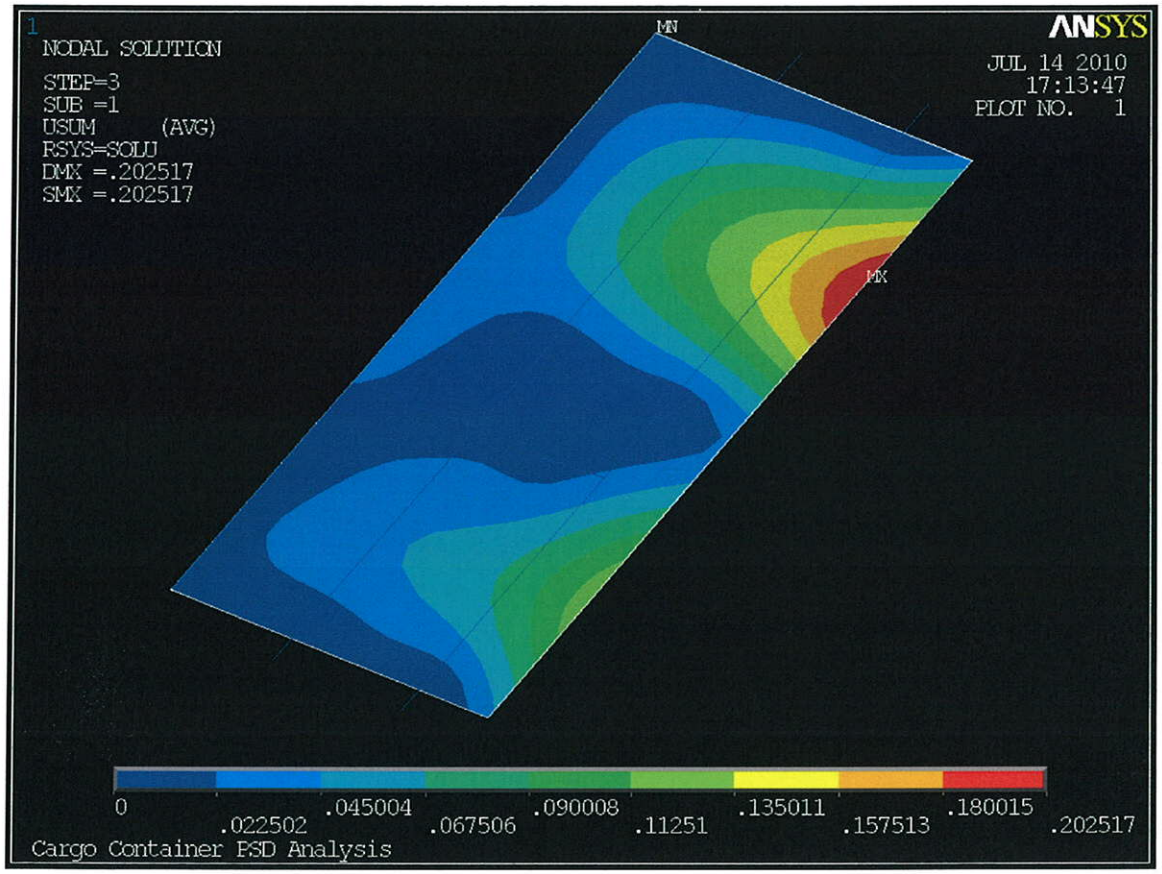



Figure 3. RMS Displacement of Cargo Container Door

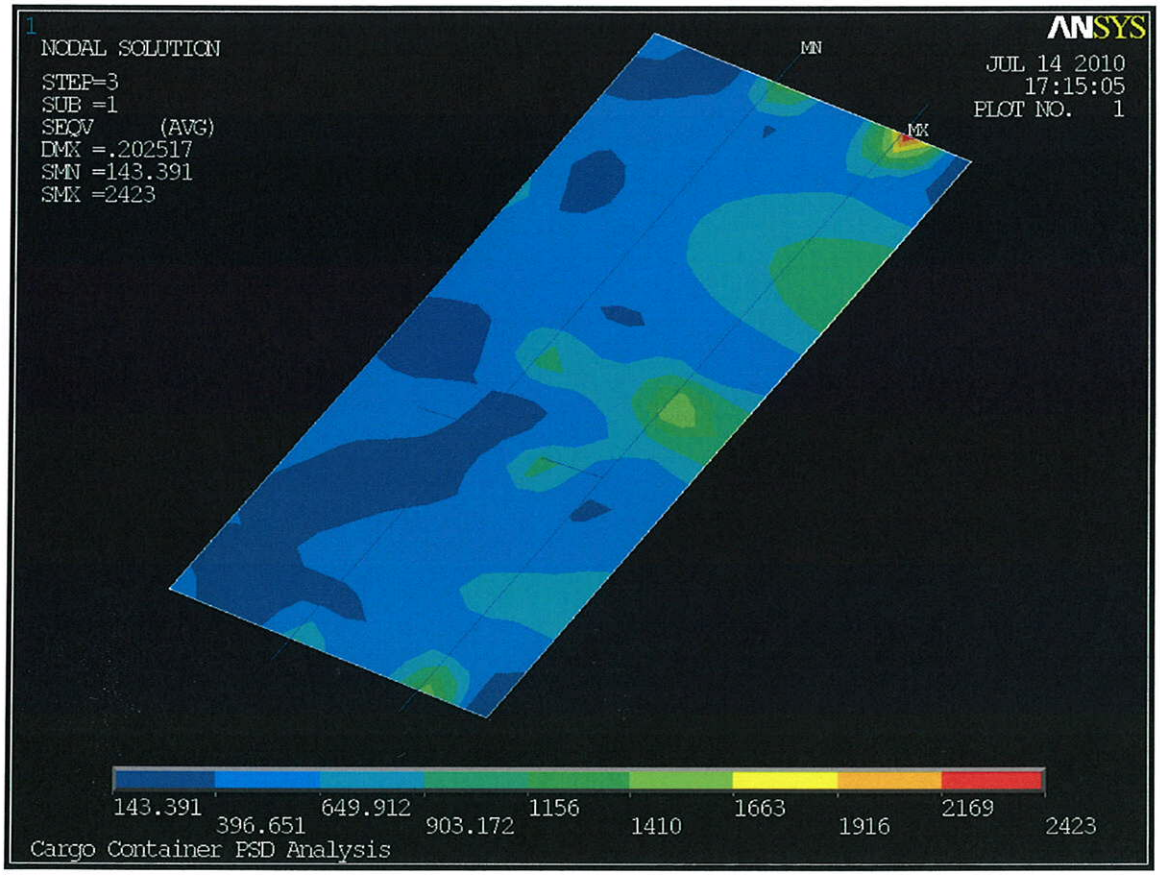



Figure 4. RMS Von Mises Stress in Door

It can be seen that in Figure 4 that the Von Mises stress is quite small. Table 1 summarizes the stress analysis results on the door component of the closure system. Table 2 summarizes the loading on the securement bars' anchor lugs and weld stress. It can be seen from the table that these loads and stresses are also quite small.

**Table 1. Cargo Container Door Stress During NCT**

| Yield Stress ($\sigma_Y$) | Maximum Stress (RMS) | Factor of Safety |
|---|---|---|
| 36,000 psi | 2,423 psi | 15 |

**Table 2. Securement Bar Anchor Lug Loads and Weld Stress**

| Anchor Lug Horizontal Shear ($F_H$) | Anchor Lug Vertical Shear ($F_V$) | Anchor Lug Bending Moment (M) | Anchor Lug Torsional Moment (T) | Allowable Anchor Lug Weld Stress ($0.4* \sigma_Y$) | Maximum Anchor Lug Weld Stress* | Factor of Safety |
|---|---|---|---|---|---|---|
| 43 lbf | 23 lbf | 135 in-lbs | 782 in-lbs | 14,400 psi | 1,823 psi | 8 |

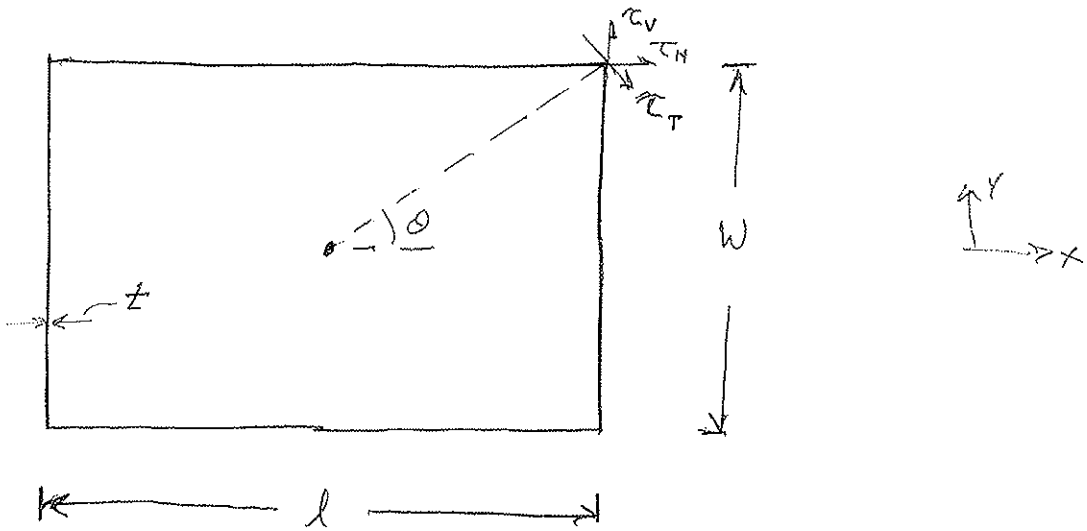
*See attached weld stress analysis

**Conclusion**

The random vibration loading incurred by the cargo container during NCT results in low loads and stresses on the closure system and consequently a high margin of safety against any loss of structural integrity.

$W = 1$ in, $l = 3$ in, $t = 0.16$"
$\theta = \tan^{-1}(W/l)$

# Anchor Lug Weld Stress Estimate







$\theta = \tan^{-1}(W/l) = 18.4°$

$$I_w = 2\left(\frac{1}{12}\frac{t}{\sqrt{2}}W^3\right) + 2\frac{t}{\sqrt{2}}l\left(\frac{W}{2}\right)^2 = \frac{1}{6\sqrt{2}}tW^3 + \frac{1}{2\sqrt{2}}tlW^2$$

$$J_w = \frac{1}{6\sqrt{2}}t(l+W)^3 = 1.21\ in^4 \qquad = 0.19\ in^4$$

$$A_w = \sqrt{2}(l+W)t = 0.91\ in^2$$

$$\sigma_z = \frac{MW}{2I_w}, \quad \tau_T = \frac{T\sqrt{W^2+l^2}}{2J_w}, \quad \tau_V = \frac{F_V}{A_w} \text{ \& } \tau_H = \frac{F_H}{A_w}$$

| $F_H$ | $F_V$ | $M$ | $T$ |
|---|---|---|---|
| 43 lbf | 23 lbf | 135 in-lbs | 782 in-lbs |

| $\sigma_z$ | $\tau_T$ | $\tau_V$ | $\tau_H$ |
|---|---|---|---|
| 355 psi | 1,022 psi | 47 psi | 25 psi |

$$\therefore \quad \tau = \left((\tau_T\cos\theta + \tau_H)^2 + (\tau_V - \tau_T\sin\theta)^2\right)^{1/2} = \underline{1032\ psi}$$

$$\therefore \quad \sigma_E = \sqrt{\sigma_z^2 + 3\tau^2} = \underline{1,823\ psi}$$

$$\sigma_{allow} = 14,400\ psi$$

$$\therefore \quad n = \frac{\sigma_{allow}}{\sigma_E} = \underline{8}$$

7.14 The **Disposal Operations Technician** assembles the waste shipment documents and forwards to the LLNL Traffic Office.:

- Bill of Lading.
- LLNL Shipping Document.
- Packing List, if applicable.
- *741 Information Sheet* (SDF0001), if applicable *PSDR Report Form.*
- *Exc*lusive Use Instructions, if applicable (DOT regulated shipments).
- Driver Instructions, if applicable (non-DOT shipments).
- Emergency Response Information Sheet for shipping LLW (copied from the Emergency Response Guide), if applicable.
- NNSS Advance Notification of Shipment.

7.15 After the LLNL Traffic Office reviews and initials the original copy of the waste shipment documents, they return the original copy of the waste shipment documents to the Disposal Technician. If shipment documents require changes, the **Disposal Operations Technician**:

- Corrects the shipment documents.
- Returns the corrected shipment documents to the LLNL Traffic Office and WCO for review and acceptance.
- Updates all other informational copies being reviewed.
- Records that each document final copy is completed on the *NNSS Shipment Documentation Package Checklist* (SDF0021).

7.16 The **Disposal Operations Technician** completes Section I of the *RHWM Radioactive Shipment Checklist* (SDF0003) or assures that the steps are completed prior to the arrival of the transport vehicle as follows:

- If the container to be shipped is a cargo container:

  a. The container has a PATS QA sticker indicating it was purchased in accordance with PATS procurement procedures, inspected, and found to be acceptable.
  b. The gross weight of the container does not exceed 45,000 pounds.
  c. The loaded container meets the physical and chemical compatibility requirements of 49CFR 173.410 (g).

- If the cargo container meets all three criteria, it meets the requirements of an IP-1 container and shall be marked “USA Type IP-1”. Record all three

required criteria on the *RHWM Radioactive Shipment Checklist* (SDF0003).

**NOTE**

Certification of the container is confirmed by the Disposal Operation Technician signing the shipping document.

- Initials and dates each step of the *RHWM Radioactive Shipment Checklist* (SDF0003) as the step is completed.
- Signs the *RHWM Radioactive Shipment Checklist* (SDF0003) when Section I of the form is complete and notifies the Storage Operations Technician.
- Contacts the LLNL Traffic Office to perform container inspections.

7.17 The **Disposal Operations Technician**:

- Obtains the signed 741 Information Sheet from DOE/ LSO through the Materials Management Section (received in 7.8 if applicable).
- Obtains the approved NNSS authorization to ship waste from the Materials Management Section, if applicable.
- Updates the waste shipment document package by replacing the 741 Information Sheet (SDF0001) with the signed 741 Information Sheet if applicable.
- Consolidates additional original documents into the shipment documentation package which may include:
    - Bill of Lading.
    - LLNL Shipping Document.
    - Packing List, if applicable.
    - LLW Certification Statement.
    - PSDR.
    - Emergency Response Information Sheet for shipping LLW (copied from the Emergency Response Guide), if applicable.
    - Exclusive Use Instructions, if applicable (DOT regulated shipments).
    - Driver Instructions, if applicable (non-DOT shipments).

f. Assure that the following shipment documentation is complete and accurate. Record applicable dates and times on the ~~NTS~~NNSS Shipment Certification Checklist:

- PSDR; review at least 10% (arbitrarily chosen) of the radiological data against RHWM Radioactive Shipment Spreadsheet.
- Packing List, if applicable.
- Bill of Lading (or manifest for MW).

g. Complete a ~~*Low Level*~~ *Waste Certification Statement* (WCP 0034), obtain the WCO's signature and submit to the RHWM ~~Shipping~~ Disposal Office. For MW, the WCO signs an LDR Certification Statement in lieu of WCP 0034.

h. For waste containing TRU nuclides in excess of 100 nanocuries per gram, notify NSTec by fax prior to shipment~~prepare a notification letter to National Security Technologies (NSTec) with a WCP memo number from the correspondence log. Fax a copy of the letter to NSTec prior to shipment~~.

i. For waste containing tritium that is to be shipped in an enclosed van, notify NSTec by fax prior to shipment.

j. Assure that the PSDR information has been electronically transferred to NSTec by the RHWM ~~Shipping~~ Disposal Office.

k. Verify that the containers prepared for shipment are identified on the RHWM Radioactive Shipment Spreadsheet and PSDR, and that the appropriate WPS(s), barcodes (shipment number, container number), markings, and labels are affixed to the containers. If shipping a cargo container, certify that it meets Industrial Packaging-I (IP-1) criteria at a minimum and verify that it is appropriately marked.

l. Generate package certification labels, which will then be signed and affixed to the containers acceptable for shipment.

m. Upon completion of the pre-shipment activities, sign and date the ~~*NTS*~~*NNSS Shipment Certification Checklist* (WCP 0012).

## 7. Shipment Activities

The following activities are performed by the ~~**RCGA**~~**RCA ~~or~~ WCO or authorized shipment certifer** unless otherwise indicated.

7.1 On the day of shipment, complete the ~~*NTS*~~*NNSS Shipment Certification Checklist* (WCP 0012) by initialing, as appropriate, after performing the following steps:

a. Assure that the results of the non-fixed radioactive contamination survey and the external radiation survey of the transport vehicle are acceptable through consultation with the Disposal Operations Technician.

b. Verify that the correct ~~LLW~~ waste containers are properly loaded and secured to assure that container integrity will not be compromised.

c. Verify that the following shipment documentation has been provided to the driver and check the appropriate boxes on the ~~*NTS*~~*NNSS Shipment Certification Checklist* (WCP 0012).

- PSDR with correct date.
- Packing List, if applicable, with correct date and time.

# ~~NTS~~NNSS SHIPMENT CERTIFICATION CHECKLIST

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Shipment Number: _____Total Number of Containers in Shipment: _____Shipment Date: _____

**PRE-SHIPMENT ACTIVITIES:**

*Initials*

_____RHWM Radioactive Shipment Spreadsheet is complete and accurate. Date _____Time _____

_____The containers identified have been certified for shipment to ~~NTS~~NNSS, and the radionuclides are within the ranges identified on the waste profile.

_____The DOT information has been reviewed and is acceptable.

_____☐NA. NRC Form 741 is required and complete.

_____There are no open NCARs for the waste packages identified on the PSDR.

_____The shipment documents, listed below, are complete and accurate.

_____Package, Storage and Disposal Request: Date _____

_____☐ NA. Packing List: Date _____Time _____

_____Bill of Lading (for LLW) or Manifest (for Mixed waste)

_____~~LLW~~ Waste Certification Statement ~~(for LLW) or LDR Certification (for MW)~~ is complete.

_____☐ NA. For waste containing TRU nuclides in excess of 100 nCi/gram, NSTec was notified~~a notification letter was provided to NSTec~~.

_____☐ NA. For waste containing tritium that is being shipped in an enclosed van, NSTec was notified.

_____Package, Storage and Disposal Request (PSDR) has been electronically transferred to NSTec by the shipping coordinator.

_____Containers prepared for shipment are those identified on the Package, Storage and Disposal Request (PSDR).

_____The appropriate barcodes, markings, and labels are affixed to the containers.

_____Cargo container is certified to meet IP-1 criteria at a minimum and marked appropriately.

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Pre-Shipment Activities Complete: _____ _____

~~RCGA~~ Shipment Certifier Signature Date

**SHIPMENT ACTIVITIES:**

*Initials*

_____Results of the non-fixed radioactive contamination survey and the external radiation survey of the transport vehicle are acceptable.

_____The correct LLW containers are properly loaded and secured to assure that container integrity will not be compromised.

_____The following documents have been given to the driver:

☐ Bill of Lading (for LLW) or Manifest (for MW)
☐ LLW Certification Statement (or LDR Certification for MW)
☐ Package, Storage and Disposal Request with correct date
☐ Route Instructions
☐ NA ☐ Packing List with correct date and time
☐ NA ☐ Exclusive Use and Drivers Instructions
☐ NA ☐ Emergency Response Guide

_____☐ NA Copy if the shipping documentation has been placed in the enclosed trailer.

_____☐ NA The appropriate placards have been appropriately applied to the transport vehicle.

_____☐ NA Security seal(s) are affixed to the trailer. Seal # _____

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Shipment Activities Complete: _____ _____

~~RCGA~~Shipment Certifier Signature Date

**SHIPMENT FOLLOW-UP:**

*Initials*

_____DOE/OAK notified of shipment.